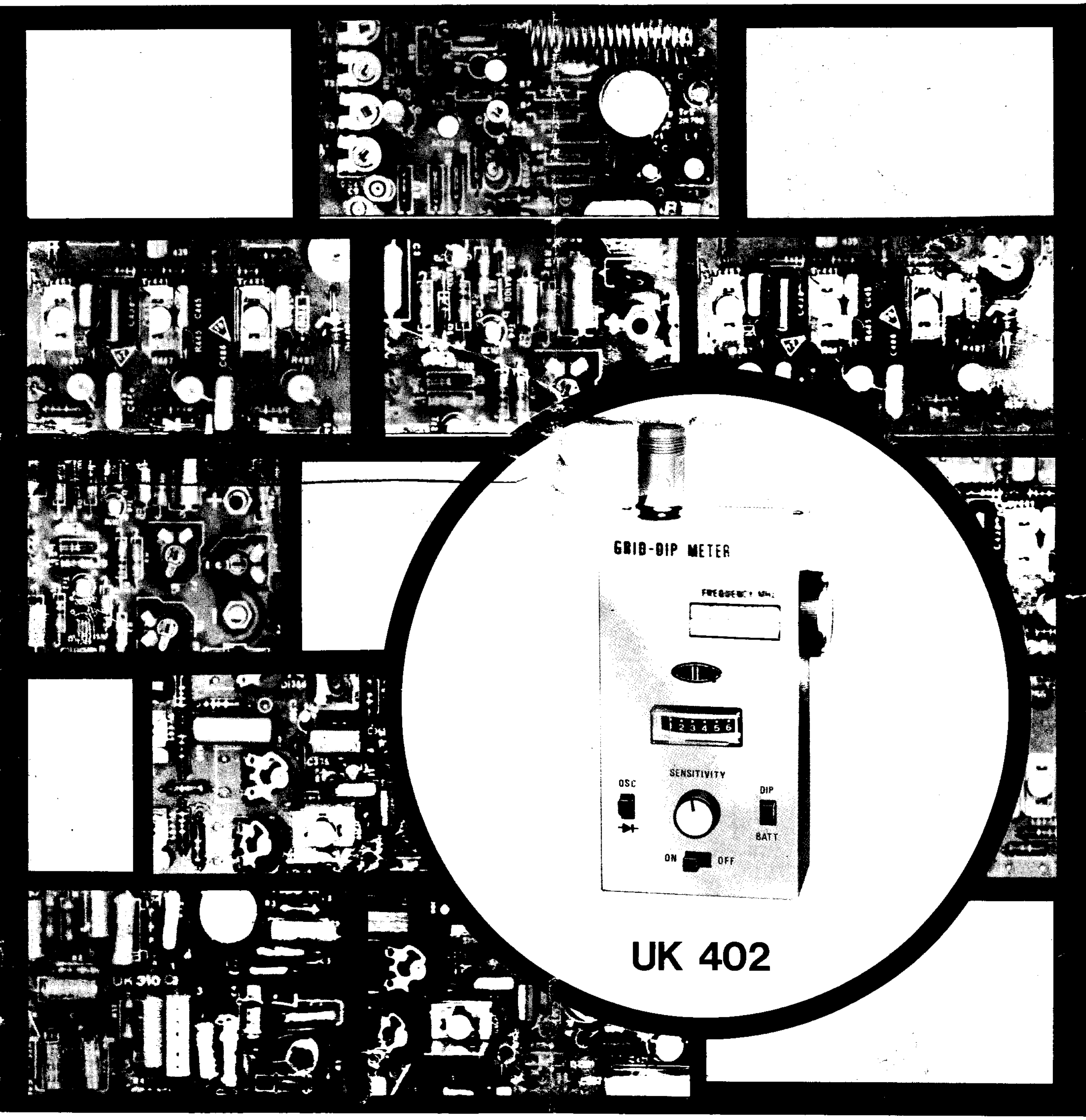
AMTRON®

GRID-DIP METER



UK 402

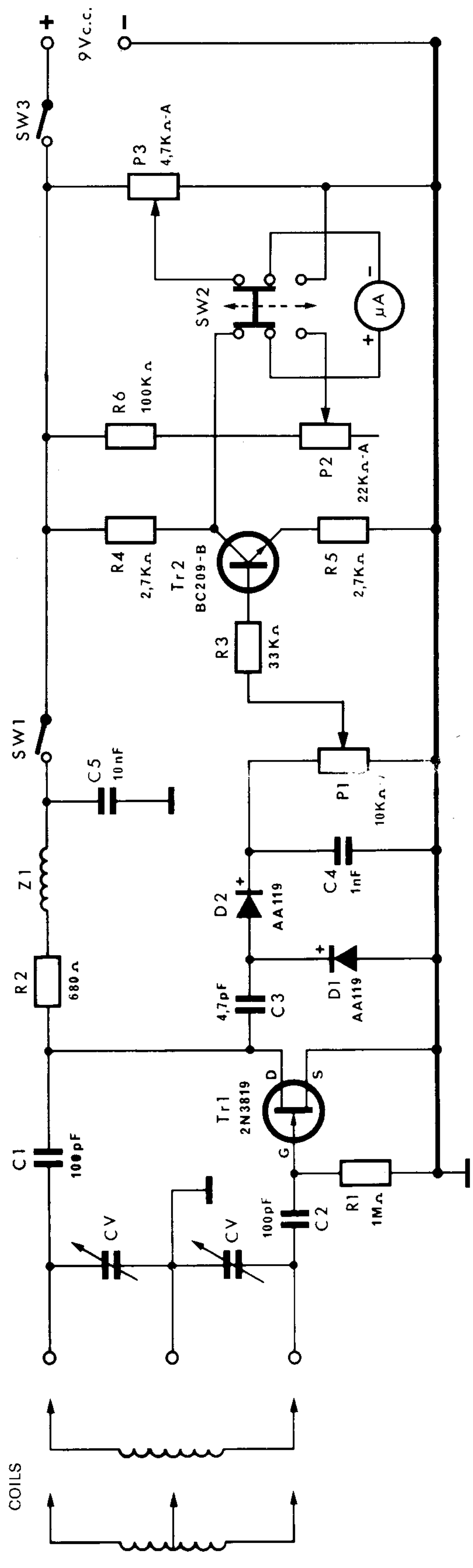


Figure 1 - Circuit Diagram.

TYPICAL CHARACTERISTICS

Power supply: 9 V from built-in batteries (6 x 1.5 V)

Current drain from battery: 8 mA

Frequency range:
from 2.8 – 155 MHz subdivided in five ranges:

I from	2.8	–	7 MHz
II from	6	–	13 MHz
III from	11.5	–	27 MHz
IV from	26	–	64 MHz
V from	60	–	155 MHz

Transistors used: FET 2N3819, BC209B

Diodes used: 2-AA119

In strictly rigorous terms, the instrument presented here should be correctly called an «Absorption wavemeter», but the term «grid-dip» has now entered into the language used by electronic enthusiasts. The new instrument presented here in this kit differs from the versions which have appeared previously in that it uses a FET oscillator which gives it a much greater sensitivity and precision.

The radio frequency voltage detector is a separate part of the circuit and its output is amplified in order to increase the sensitivity. One can use the instrument without the oscillator and as such the instrument operates as a means for selectively measuring electro-magnetic fields.

The scale calibration accuracy is of a high order. By using a printed circuit for the high frequency circuit with only a small number of wire connections, by keeping the mechanical construction as rigid as possible and by using 5 pre-calibrated coils for the separate frequency ranges, the variation between different instruments due to variations in construction has been reduced to a minimum.

A switch placed at an appropriate point in the circuit allows the battery state to be checked at any time.

If one could give a prize for the most versatile and useful instrument available to amateur enthusiasts who use high frequencies, it would undoubtedly go to the «grid-dip». In a «professional» sense this instrument, limited in its precision only by the scale calibration, cannot perhaps compete with a series of more or less complicated laboratory measurements. However, its simplicity and ease of handling, together with its vast field of measurement makes it indispensable to all those measurements which require not so much a high degree of accuracy as a certain amount of practicality and speed. The name of this instrument comes from the time when it was first constructed using val-

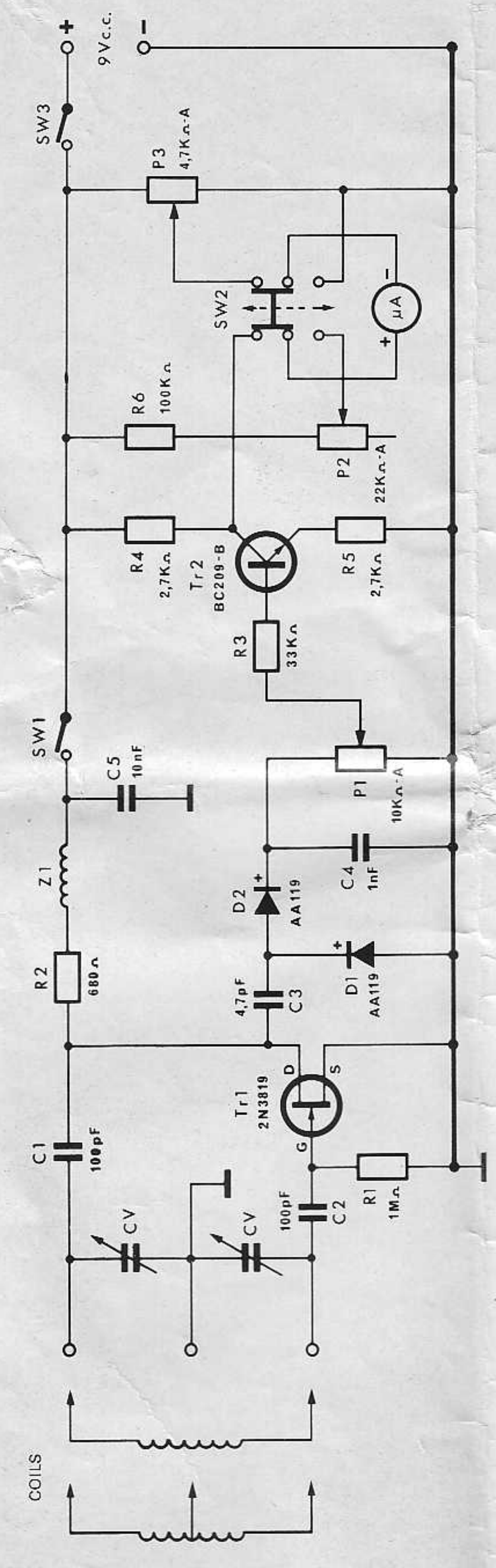


Figure 1 - Circuit Diagram.

TYPICAL CHARACTERISTICS

Power supply: 9 V from built-in batteries (6 x 1.5 V)

Current drain from battery: 8 mA

Frequency range:
from 2.8 — 155 MHz subdivided in five ranges:

I	from	2.8	—	7 MHz
II	from	6	—	13 MHz
III	from	11.5	—	27 MHz
IV	from	26	—	64 MHz
V	from	60	—	155 MHz

Transistors used:
FET 2N3819, BC209B

Diodes used: 2-AA119

In strictly rigorous terms, the instrument presented here should be correctly called an «Absorption wavemeter», but the term «grid-dip» has now entered into the language used by electronic enthusiasts. The new instrument presented here in this kit differs from the versions which have appeared previously in that it uses a FET oscillator which gives it a much greater sensitivity and precision.

The radio frequency voltage detector is a separate part of the circuit and its output is amplified in order to increase the sensitivity. One can use the instrument without the oscillator and as such the instrument operates as a means for selectively measuring electro-magnetic fields.

The scale calibration accuracy is of a high order. By using a printed circuit for the high frequency circuit with only a small number of wire connections, by keeping the mechanical construction as rigid as possible and by using 5 precalibrated coils for the separate frequency ranges, the variation between different instruments due to variations in construction has been reduced to a minimum.

A switch placed at an appropriate point in the circuit allows the battery state to be checked at any time.

If one could give a prize for the most versatile and useful instrument available to amateur enthusiasts who use high frequencies, it would undoubtedly go to the «grid-dip». In a «professional» sense this instrument, limited in its precision only by the scale calibration, cannot perhaps compete with a series of more or less complicated laboratory measurements. However, its simplicity and ease of handling, together with its vast field of measurement makes it indispensable to all those measurements which require not so much a high degree of accuracy as a certain amount of practicality and speed. The name of this instrument comes from the time when it was first constructed using val-

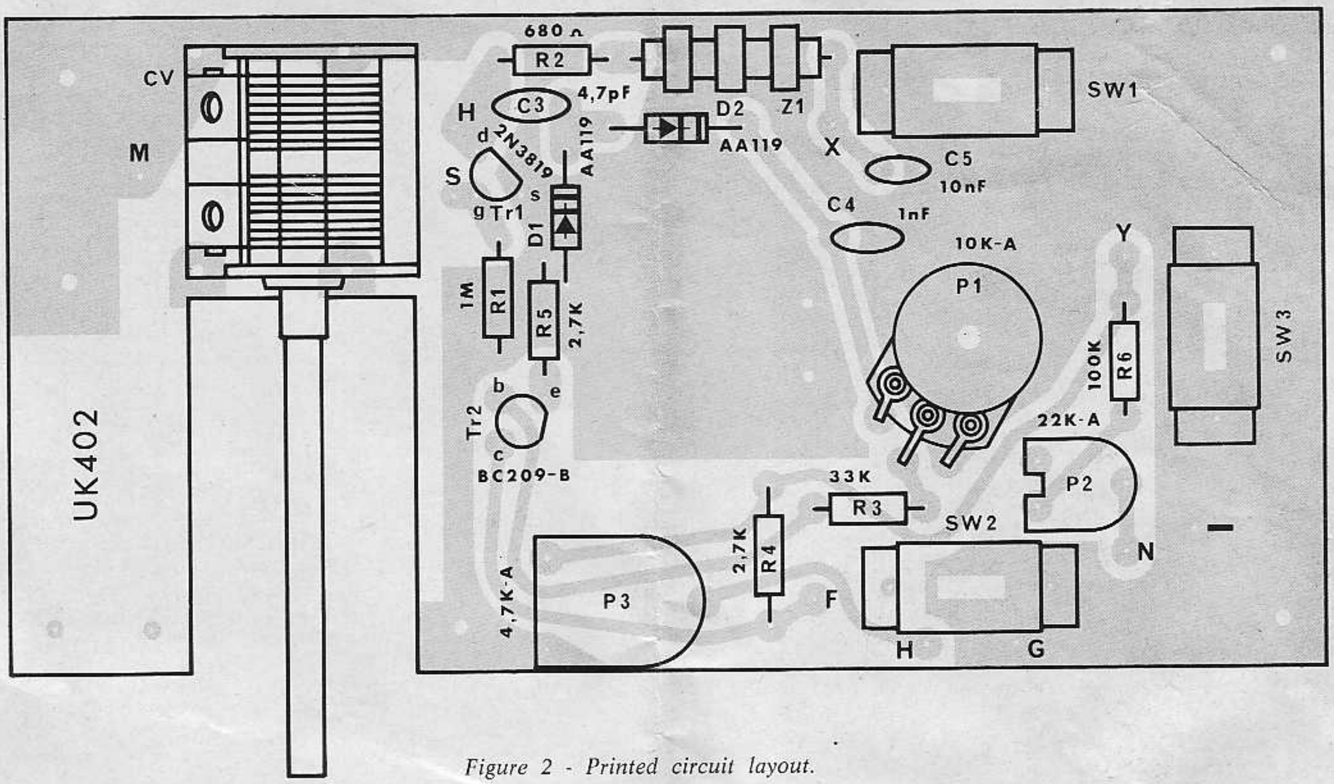


Figure 2 - Printed circuit layout.

ves. The oscillator, which is the heart of the instrument, must operate in class C which means, when using valves, that there is a certain amount of grid current. This current has a fixed value if the oscillator circuit loading the oscillator does not take any power. If, however, one couples another closed circuit to this oscillator the result is the same as if one loads the oscillator with a resistance determined by the physical characteristics of the other circuit and proportional also to the degree of coupling between the two circuits. The circuit absorbs energy from the oscillator and as a result produces a reduction in the feedback with a consequent lowering of the grid current. Since an oscillator circuit absorbs the maximum energy when it is exactly tuned to the oscillator frequency, then as will be shown later, it becomes possible to use the instrument to measure the resonant frequency of a parallel tuned circuit.

There will be, therefore, a reduction on the grid current when the frequency of the «grid-dip» oscillator is the same as that of the circuit under examination. The instrument can make this measurement only on parallel tuned circuits, but this does not provide any real limitation, because most oscillator circuits in radios are of this type and because the resonance frequency of a series circuit is exactly the same as that of a parallel circuit formed from the same components. Later, a number of measurements and checks which one can carry out with the grid-dip will be given, but the list will obviously be incomplete because one can, with practice, always find new applications.

Naturally, in these days it would be unreasonable to use vacuum tubes for portable instruments. The grid-dip has thus graduated to the solid state version, keeping only its name as a memory of the age when valves were the only way to build up electronic circuits. The grid-dip of today is based on the transistor, but the characteristics of the transistor, whilst proving ideal for amplifiers, are not so suitable for the present purpose. This is because the transistor has a very low input resistance and this damps pratically every circuit connected to it. As a result the «dip» of the transistor is much less than that obtained using a valve. Now, however, there is available the FET which combines the high input resistance of a valve together with the small size, low power requirements and the mechanical robustness associated with transistors. In this kit a junction FET is used. The way in which this particular type of semiconductor device operates will not be described in this instruction leaflet, and those who are interested should consult the appropriate text books.

A more detailed examination will now be made of the operation of tuned circuits. A tuned circuit is made up effectively of an inductance and a capacitance in series or in parallel. There are some differences between these two arrangements but they are not important for the present application. Resonance will occur in the circuit when the capacitive reactance is equal to the inductive reactance. Formulae showing how this occurs can be found in a number of specialised text books. The resonance occurs for one and only one frequency and at this frequency some interesting effects happen. The circuit behaves as if it did not contain any reactive elements and as a result the phase of the input signal is equal to that of the output signal. In the ideal case as described above the following will occur:

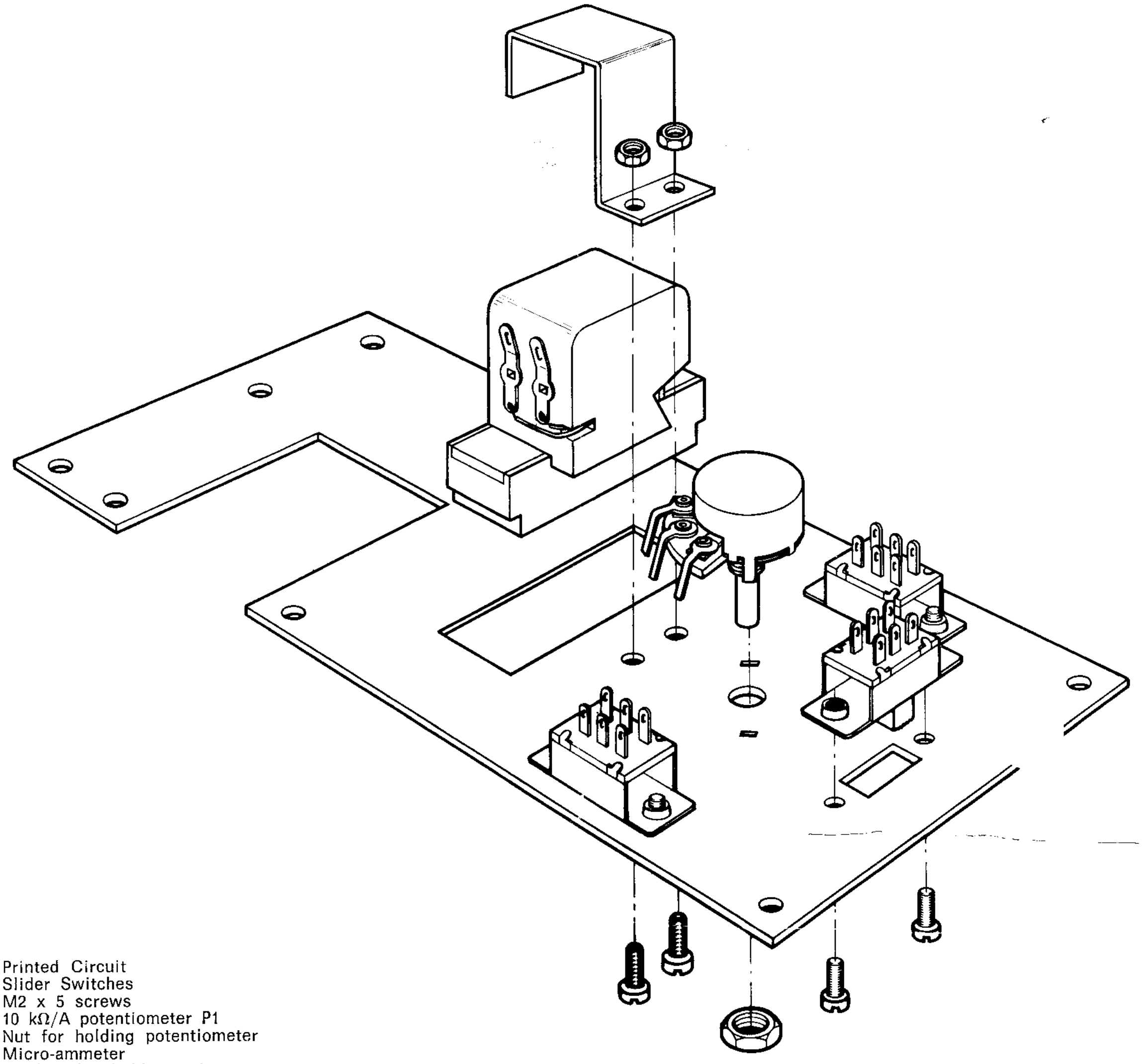
The parallel resonance circuit has a resistance which becomes theoretically infinite at resonance.

The series resonance circuit has a resistance which becomes theoretically zero at resonance.

These theoretical values are limited by the existence of various resistances present in the circuit. However, the resistance of a parallel tuned circuit will be relatively high and that of a series tuned circuit will be relatively low at resonance. The factor which describes the effect of the resistance is the so called Q-factor, or figure of merit:

$$Q = \frac{\omega L}{R}$$

The higher the Q-value the lower will be the resistance at resonance in a series tuned circuit and the higher the resistance of a parallel tuned circuit. The figure of merit also has an effect on the response curve of the circuit obtained by plotting the frequency as the abscissa and the voltage across the circuit as the ordinate. Such a curve will show either a maximum or a minimum (according to whether the circuit is a parallel or a series circuit), corresponding to the re-



1 Printed Circuit
2 Slider Switches
3 M2 x 5 screws
4 10 kΩ/A potentiometer P1
5 Nut for holding potentiometer
6 Micro-ammeter
7 Bracket for holding micro-ammeter
8 M2.6 x 6 screws
9 M2.6 nuts

Figure 3 - Mounting the components on the printed circuit.

sonant frequency. The shape of the curve away from resonance will have the well known bell shape of a pass band curve. The band-width is expressed as the interval between the two frequencies at which the response drops to a value equal to 0.707 of the maximum value (this description is valid for parallel circuits; for series circuits the terms must be reversed) and is very much narrower when the Q-value of the resonance circuit is higher. The voltage which one obtains across the circuit increases with increase of Q and for this reason is also called the voltage multiplication factor. One can see, therefore, the importance of this factor in a radio frequency amplifier where it is better to operate on the voltage rather than the current.

Before describing the detailed operation of the UK 402 a summary of the various uses one can make of it will be presented. The main scope of the grid-dip is that of measuring the resonant frequency of a parallel LC circuit to which it is coupled. To carry out this measurement the circuit under test does not need to be switched on because the oscillator contained in the instrument provides all the signal required through the effect of mutual inductance.

The instrument can also be used as a tuned detector and in this case one can check the existance and make an appropriate measurement of the intensity of electromagnetic fields produced by other oscillators.

Measurement of the resonant frequency of a parallel circuit

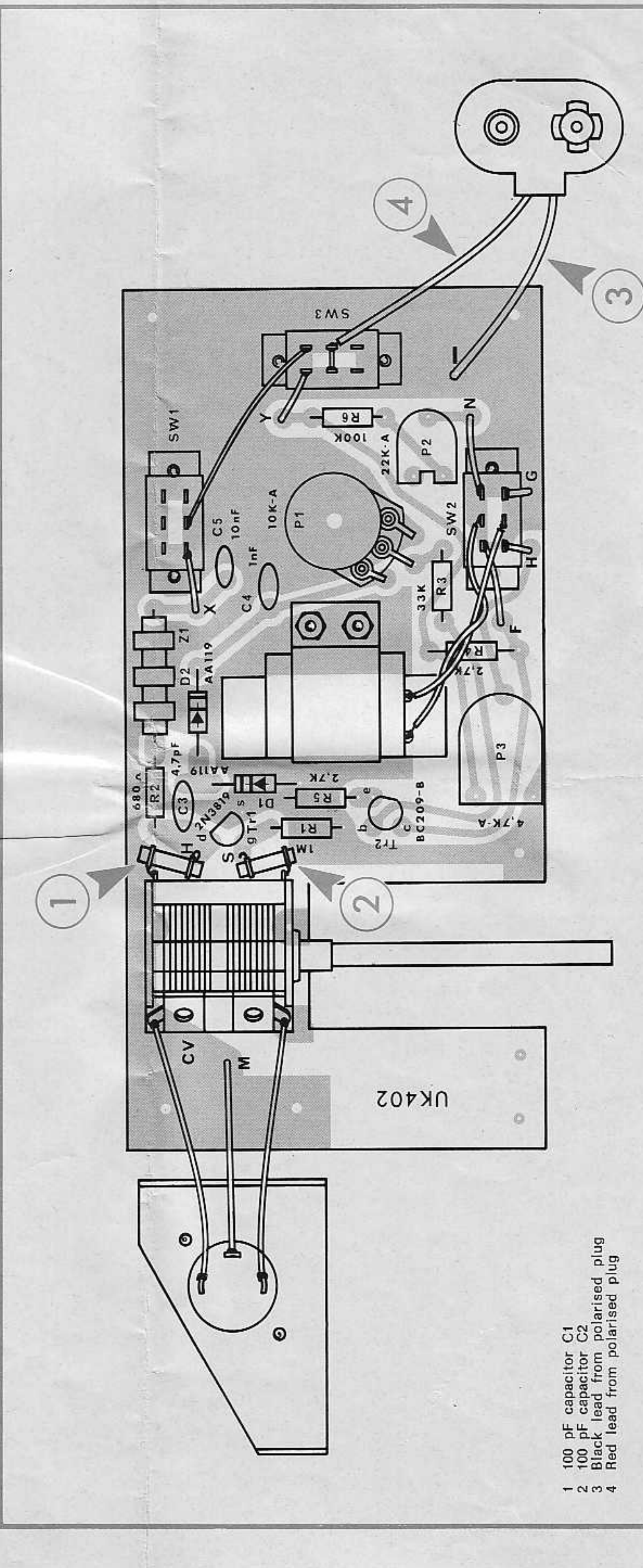
The measurement is carried out by first connecting an inductor of unknown value in parallel with a capacitor of unknown value. If the resonant frequency of this circuit, which is not connected to any signal source but is left completely isolated, is within the measurement range of the grid-dip, then the resonance can be detected by keeping the grid-dip coupled with the circuit to be measured and by tuning in until, at a certain point the meter needle suddenly jumps to a higher value. At this point one must take a certain number of precautions. If the instrument continues to show the dip also when it is some distance from the test circuit, then the dip is not caused by being tuned to the test circuit, but is due to other causes, such as, for example, strong radio frequency radiations produced by local radio or television transmitters. In such a case one must continue with the test, changing between the different coils provided with the instrument. At a certain point a jump will appear which disappears when the instrument and the circuit under test are separated by some distance from each other.

At this point one can say that this is the true dip but the measurement is not yet completed. In fact, the effect of the circuit under test upon the oscillator circuit in the instrument can produce, by mutual induction, a change in the effective inductance and thus of the oscillator frequency, thus giving rise to an error in the measurement. Therefore, it is necessary to move the apparatus further and further away from the circuit being examined, at the same time adjusting the tuning scale of the grid-dip until finally the dip of the instrument becomes independent of further distance from the circuit under test. The scale reading at this point will give an exact value of the oscillation frequency of the circuit under examination.

If this circuit is to be used as a trap or rejector circuit, that is, if it is to be used as a series-tuned circuit to short out an undesired frequency to earth, carefully disconnected from the coil and then one end of the capacitor must be the two ends of the circuit which are now free must be connected one to the high frequency transmission line of the amplifier and the other to earth.

Sometimes, in certain types of receiver, it happens that a very powerful and nearby transmitter manages to enter the intermediate frequency channel despite all attempts designed into the circuit to avoid such intermodulation. In such a case, the only remedy is to place a trap or rejector circuit at the input of the receiver which will remove that particular frequency. Once the exact frequency of the interfering station has been established using for example the grid-dip (in fact when the dip oscillator is tuned to the same frequency as the disturbing station this will become silenced by the predominant effect of the nearby oscillator), one can construct a trap circuit as described above and place this in parallel with the input of the receiver. The ratio between the capacity and the inductance of the trap circuit is selected by considering the width of the band occupied by the station which is to be removed. For a television station which transmits on a relatively large band-width, one must increase the capacitance and reduce the inductance thus increasing the band-width, one must increase the capacitance and reduce the inductance thus increasing the band-width of the trap circuit. One can, if necessary also add an attenuation resistance.

For the opposite case, one should re-



1 100 pF capacitor C1
2 100 pF capacitor C2
3 Black lead from polarised plug
4 Red lead from polarised plug

Figure 4 - Wiring and electrical connections.

duce the capacitance and increase the inductance so that the Q of the trap circuit is increased, as can be seen from the following formula which gives the band-width of a simple tuned circuit:

$$\text{Band-width at 3 dB} = \frac{\text{Resonant frequency}}{Q}$$

Note that the Q of the complete circuit is mainly influenced by the characteristics of the inductor and that at high frequencies, within certain limits, it is easier to increase Q by increasing the inductance. As a result, one can see that for narrow band-widths it is more convenient to increase the inductance and reduce the capacitance. This method will also increase the Q under load, because this will be provided by a resistance of a larger value.

Method of measuring the inductance of a coil using a known value capacity

In general the capacitance value is stamped on capacitors together with other signs showing the tolerance limits of the value and also its temperature dependance etc. Therefore, connecting a known value capacitor in parallel with the unknown inductance, one can use the grid-dip to measure the resonant frequency for the resulting circuit. One can then use the formula for the resonant frequency to find the value of the inductance:

$$L = \frac{1}{4 \pi^2 f^2 C}$$

One now has available an inductance coil with a value of inductance which is known within defined limits of tolerance. This is very convenient because, in general, it is capacitors which are made in industrial production quantities with a well defined value of the capacitance whereas inductors are nearly always made individually and their value is difficult to forecast exactly because it depends on a number of very diverse factors.

Measuring the capacitance of a capacitor

Having available an inductor with a known value of inductance and made up in such a way that its electrical and mechanical characteristics are stable, one can use it to find the unknown value of the capacitance of a capacitor such as for example, a variable capacitor (for which the value of the minimum capacitance and the maximum capacitance is unknown). Using the same system as above one finds the resonant frequency of the circuit and thus, from this, the capacitance using the following formula:

$$C = \frac{1}{4 \pi^2 f^2 L}$$

TEST GENERATOR

Because of its construction, the grid-dip is an oscillator of very high precision which radiates a certain amount of radio frequency power from the coil of the tuned circuit. One can use this radiation to calibrate a receiver to a high degree of precision. This precision is also helped by the fact that the instrument generates a very pure waveform practically free of harmonics and works in the fundamental also at very high frequencies, contrary to most other types of commercial generators.

Measurement of the characteristics of a tuned circuit in situ

With the help of the grid-dip one can evaluate the behaviour of a tuned circuit without having to disconnect it from the circuit in which it is connected. If one knows the characteristics of the isolated circuit, it is then possible to evaluate the effect of the parasitic elements such as the distributed inductance and the parasitic capacitance. Naturally, one can only measure the overall value and it is not possible to find the origins point by point within the circuit, but it should be evident that such a measurement is very useful. There have been many cases of a super-heterodyne converter not working properly because the exact value of the parasitic elements was unknown.

To make this measurement it is not necessary to have the apparatus under test in operation because the radio frequency power is provided by the grid-dip itself. If the circuit under investigation is situated in a position which is difficult to reach this can be overcome by using a so called link coupler. This is made up of a closed circuit formed by one or two turns coupled to the circuit under examination and the same number coupled to the coil of the grid-dip. Such a system provides the means of coupling the two without affecting the values being measured. One should take care, however, not to use too long a connecting lead and to make sure that the connecting leads are twisted together.

If the Q of the tuned circuit has been made artificially low as is the case of certain amplifiers used in television sets, difficulty may be experienced in using the grid-dip to read the resonant frequency. In such a case one can unsolder the damping resistance temporarily to make the measurement.

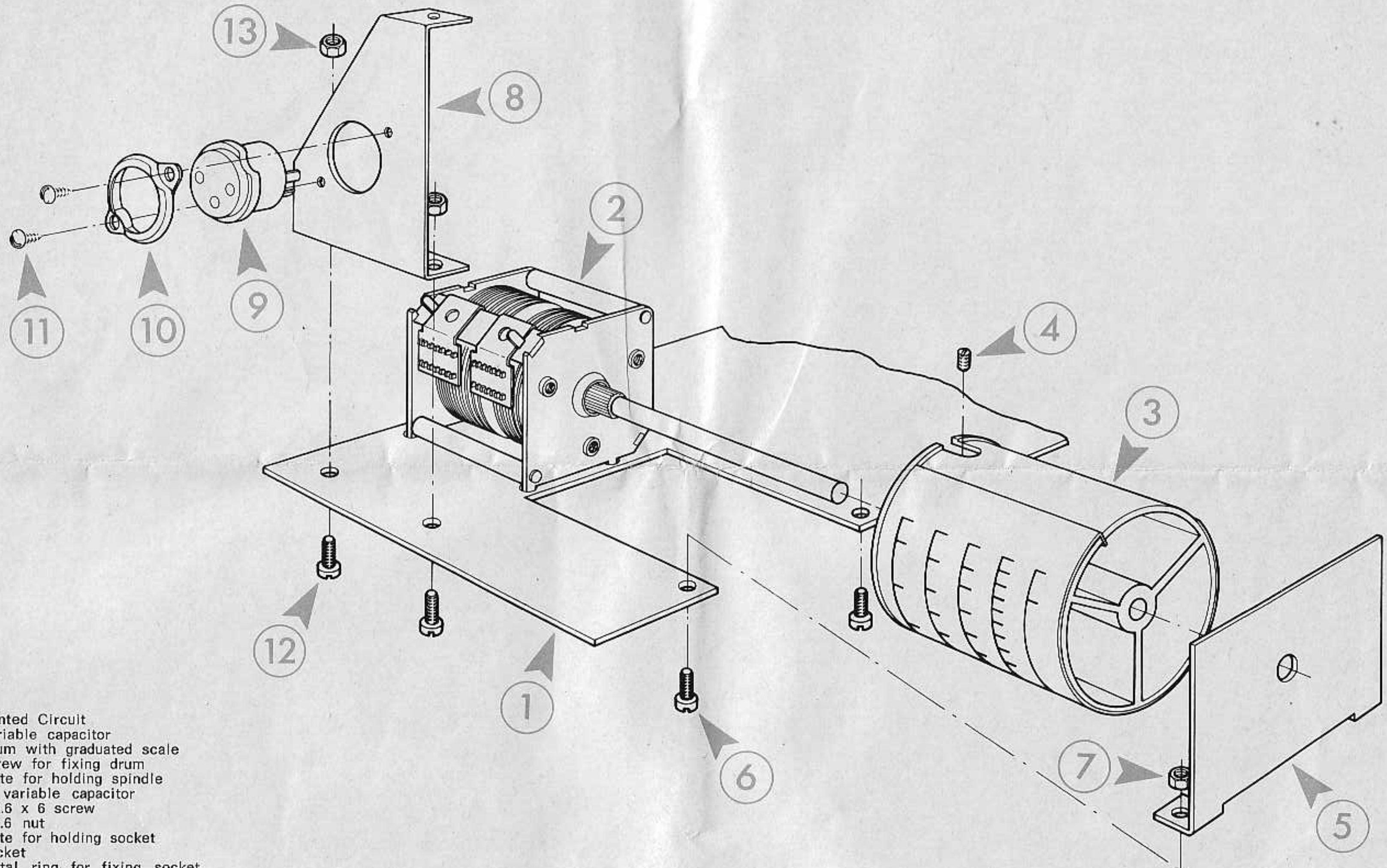
CIRCUIT DESCRIPTION

The electrical circuit consits of a FET oscillator, a double detector, and a dc amplifier which drives the instrument meter. The oscillator is made up of the FET Tr1. The FET is an ideal component for making up an oscillator. It has a high input impedance and its internal feedback is much than that of a transistor. The drain-gate characteristics can be compared to that of a pentode but without the effect of the screened grid which increases the isolation from the point of view of the capacity between the input and the output. In fact the capacity between the drain and the gate can be compared directly with that between the anode and the grid of a triode. Naturally, one cannot speak of the gate current in a FET in the same way as one speaks of the grid current in a triode. One in fact must use another method to examine the power absorption of the oscillator circuit.

The oscillator is of the variable capacity Colpitts type. The resonant circuit is formed from a twin-gang variable capacitor CV and from a number of interchangeable coils provided with the instrument. These coils are five in number and are plugged in to the appropriate socket according to the frequency range desired. The two coils for the lowest frequency ranges also have a centre tap which provides more feedback and makes it easier to initiate oscillations.

The resonant circuit is ac connected to the drain through capacitor C1. The ac feedback voltage to the gate is provided through the capacitor C2. The dc circuit is made up of the resistor R2 which limits the drain current of the FET and the choke Z1 which, together with the capacitor C5 prevents the high frequency signal from reaching the power supply. The high value resistor R1 provides the bias voltage to the gate and determines the working point. The operation is based on the simple fact that when the output is loaded, that is when there is an absorption of power from the resonant circuit, there will be a reduction in the amplitude of the radio frequency current in the drain circuit of the FET. There is in effect, therefore, a modulation of the high frequency current which is reproduced in the output of the detector formed by the combination of D1, D2, C4, P1, which removes the ac component. One is in effect using the same system of absorption modulation used in aerial circuits many years ago for many small transmittors. The detector is ac coupled by means of the capacitor C3.

The potentiometer P1 is the detector circuit load and the sliding contact feeds a fraction of the signal to the base of the next amplification stage and thus controls the sensitivity of the instrument. The transistor Tr2 amplifies the detected signal. In the absence of a signal the bias is negative. The presence of a signal will counteract this bias increasing the current between the collector and the emitter. This current reduces the voltage at the collector by the resulting drop across the load resistance R4. The potentiometer P3 is used to reset the meter until the needle is on the scale of the instrument. When absorption occurs in the resonant circuit the positive voltage from the detector is reduced and, as a result, the resistance of



1 Printed Circuit
2 Variable capacitor
3 Drum with graduated scale
4 Screw for fixing drum
5 Plate for holding spindle of variable capacitor
6 M2.6 x 6 screw
7 M2.6 nut
8 Plate for holding socket
9 Socket
10 Metal ring for fixing socket
11 2.9 x 6.5 self tapping screws
12 M3 x 6 screws
13 M3 nut

Figure 5 - Mounting the variable capacitor.

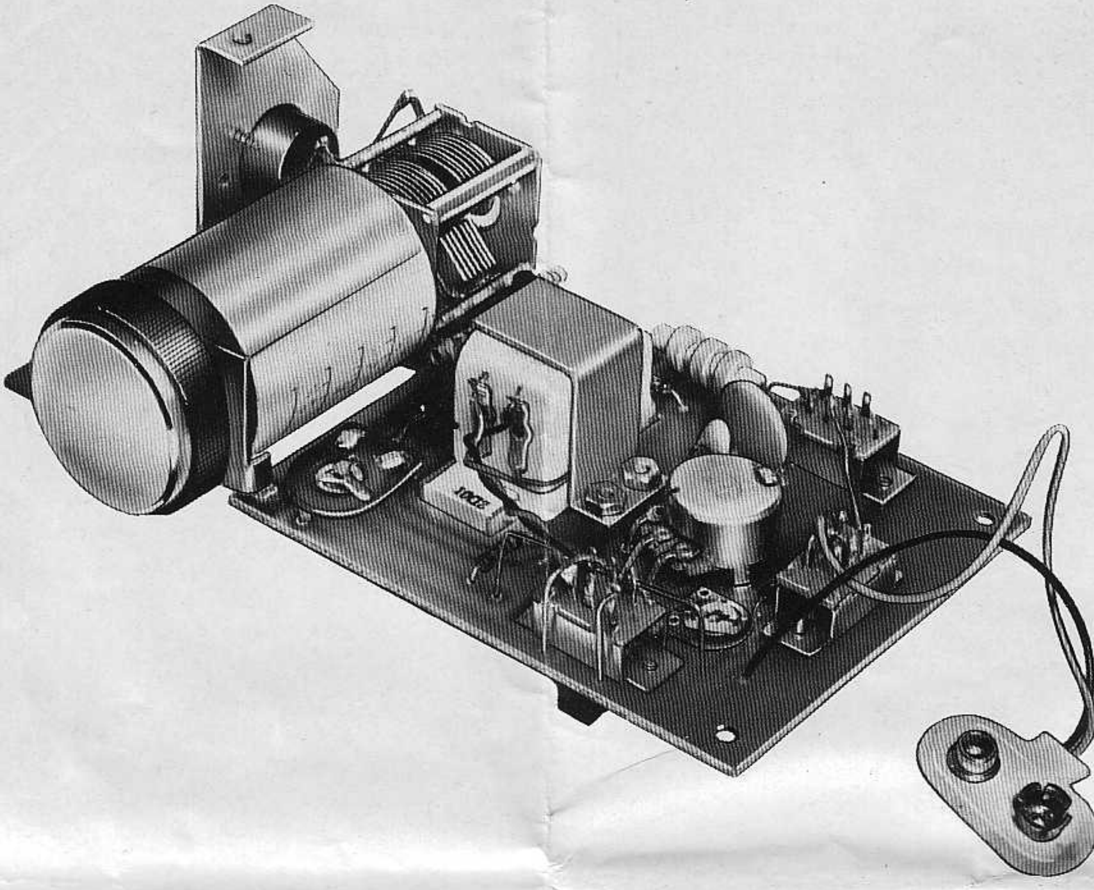


Figure 6 - Photograph showing UK 402 near final assembly.

transistor Tr2 will increase as will the voltage at the collector. This increase is shown on the meter whose needle will jump to a higher position on the scale. The effect of any temperature changes on this directly coupled amplifier have been reduced to a minimum by the use of a silicon transistor and by a sufficient amount of feedback provided by the resistor R5.

The potentiometer P2 is used to adjust the position of the meter needle to its correct point on the scale for the battery voltage check. The switch SW1 disconnnects the power supply from the oscillator. When this switch is open, the instrument will behave as a crystal detector because the signal picked-up by the tuned circuit passes directly to the detector through the capacitors C1 and C3. The rest of the circuit functions in a normal manner with an external signal as with one from the oscillator of the instrument. The switch SW2 changes the meter from its normal function to that of checking the state of the battery.

MECHANICAL ARRANGEMENT

The instrument is made up in a compact form and is easily constructed. The power supply is provided by built-in batteries. The complete circuit is arranged in a small size robust metal case. The frequency scale is divided into 5 bands with correspond to the 5 interchangeable coils provided with each instrument (fig. 8).

All the controls are placed on the front panel of the instrument with the exception of the knob which controls the variable capacitor which is on the side of the instrument to make for easier operation during measurement. The meter in the instrument is a high sensitivity microammeter. The battery container can be easily removed for changing batteries.

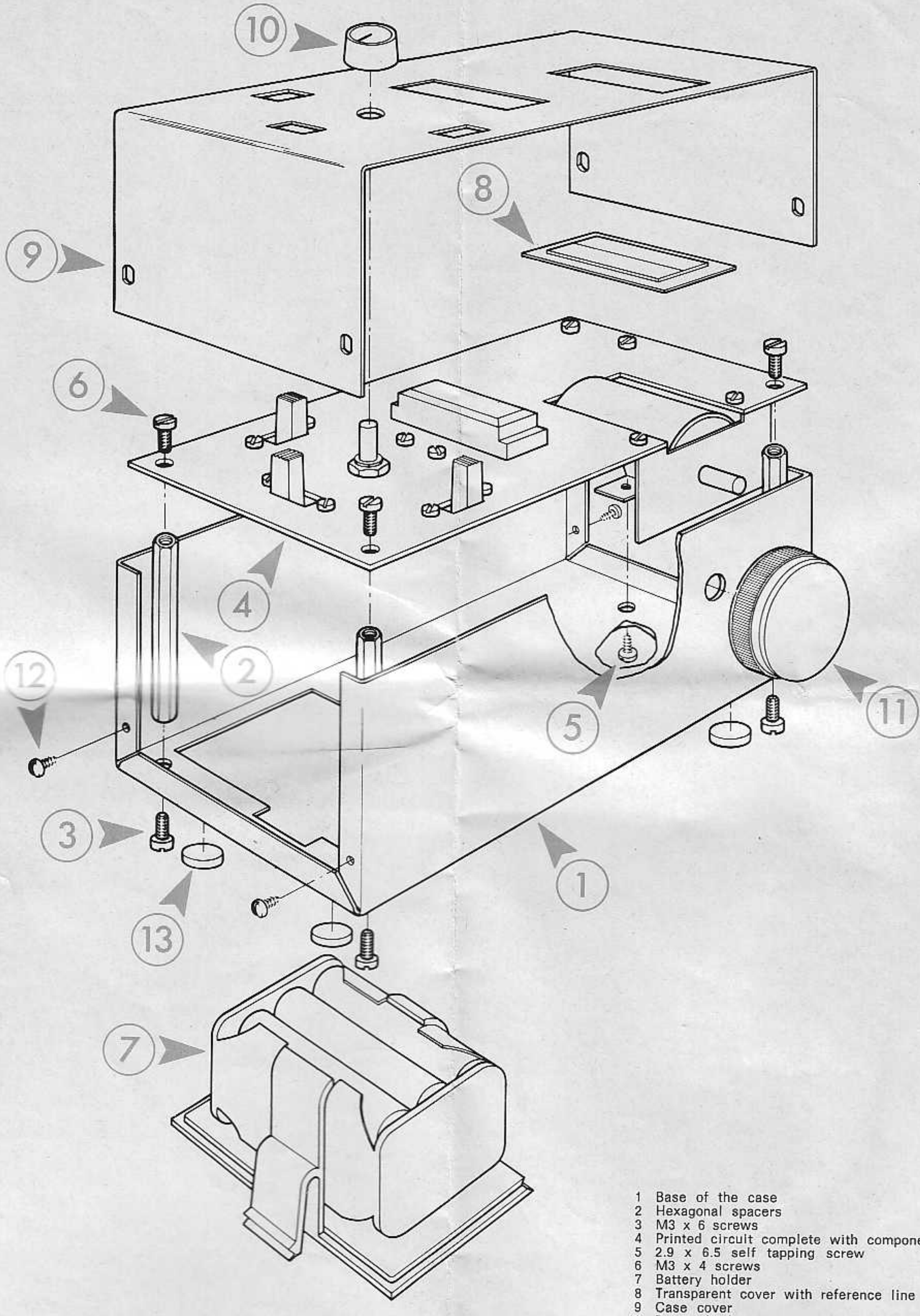
ASSEMBLY

The first stage of the assembly is the mounting of components on the printed circuit. Figure 2 shows the printed circuit layout upon which has been superimposed the exact position of each component.

First a few words of advice to those less experienced at mounting components on a printed circuit board. The printed circuit board has one surface which contains the copper connecting tracks and the other side on which the components are mounted. The components are mounted parallel and close to the surface of the printed circuit board except for some which are mounted vertically. The lead wires should be bent so that they can be inserted correctly into the holes in the printed circuit board checking each time to see that each component is being put into its correct position.

The wires are then soldered to the copper track using not too powerful a soldering iron and a rapid and decisive action to avoid overheating the component. Do not use too much solder but only enough to ensure a good contact. If the joint is not perfect first time, it is better to interrupt the work and wait for the component to cool down before repeating the attempt. These precautions apply in particular to the semiconductor components where too much heat conducted along the wires can result in a permanent change in the device characteristics and possibly, in the actual destruction of the device.

Having completed the soldering, the remaining wires sticking out from the copper track should be cut off with a pair of wire cutters to leave about 2 - 3 mm of wire protruding above the copper surface. During soldering take great care not to leave any bridges of solder between adjacent copper tracks. Pola-



1 Base of the case
2 Hexagonal spacers
3 M3 x 6 screws
4 Printed circuit complete with components
5 2.9 x 6.5 self tapping screw
6 M3 x 4 screws
7 Battery holder
8 Transparent cover with reference line
9 Case cover
10 Pointer-knob
11 Knob for the variable capacitor
12 2.2 x 5 Self tapping screws
13 Self adhesive felt pads

Figure 7 - Final assembly.

rised components such as diodes, transistors, etc., require additional care to make sure that they are inserted in the circuit the right way round because any mistakes here can give rise to a malfunction in the apparatus and probably to the complete destruction of the component the moment the apparatus is switched on. At each point in the assembly where these components are to be inserted, full instructions will be given to ensure that they are inserted correctly.

One part of the assembly consists of a high frequency tuned circuit. The components of this part of the circuit must be handled with great care. The oscillator has been pre-calibrated and therefore in order that the scale does not show the wrong reading care must be taken not to deform the variable capacitor or the coil, and also to keep any wire connections in this section as short and as straight as possible. Also in the high frequency oscillator circuit there is the junction FET amplifier. In order to solder this element directly on to the printed circuit, one must take all the normal precautions when soldering the terminal wires to avoid any damage to the gate junction.

1st Stage - Assembling the printed circuit

☐ Mount the resistors R1, R2, R3, R4, R5, R6 on the printed circuit.

☐ Mount the ceramic disc capacitors C3, C4, C5. These capacitors must be mounted in a vertical position and should be pushed against the component side of the printed circuit before soldering, but without using too much pressure such that the leads on the capacitors become broken or disconnected.

☐ Mount the two diodes D1 and D2 (AA119). These components are polarised. A ring stamped on the outer case marks the positive terminal.

☐ Mount the transistor Tr2. This component is polarised. Take care to make sure the correct leads are inserted in the corresponding holes on the printed circuit marked e, b, c. In the figure the arrangement of the terminals is shown as seen from the side they are inserted from.

☐ Mount the choke Z1. The wire with which this coil is wound is extremely fine and care must be taken not to break it especially at the points where the connections are made.

☐ Mount the two potentiometers P2 and P3. These two potentiometers are of different values so make sure that they are placed in their correct positions.

2nd Stage - Mounting the fixed components on the printed circuit

☐ The printed circuit side facing towards the front panel is the one with the copper strips and from this side there should emerge the control levers, spindles and other means for controlling or reading the performance of the instrument. Keeping this in mind mount the three 2-way change-over switches (2) on the printed circuit board (1) using the two screws (3).

☐ Mount the potentiometer P1 (4). The spindle should be pushed through the appropriate hole with the three tags positioned so they can be connected into their respective holes in the printed circuit board (see fig. 2). Fix the potentiometer with the nut (5). Solder the three tags and cut away the unused wire in accordance with the general instructions given above.

☐ Mount the micro-ammeter (6) by pushing the front face of the meter into the slot cut for it in the printed circuit board. The meter is held in place with the bracket (7) which is fixed to the board using the two screws (8) and their respective nuts (9). Make sure that the tags on the instrument are positioned as shown in the figure.

3rd Stage - Wiring connections

The arrangement of the tags which are referred to in this part are those which appear as shown in figure 4. For the switch connections, where no other instruction is given, use 0.7 mm diameter bare wire.

☐ Switch SW1
Connect the lower left tag with the point marked X on the printed circuit board. Connect the lower centre tag with the top right tag of switch SW3 using a length of bare wire.

☐ Switch SW3
Connect the top left tag with the point marked Y on the printed circuit board. Connect the two centre contacts of the switch together and connect the red lead (4) of the polarised battery plug to this point.

☐ Connect the black lead (3) of the polarised battery plug to the point marked «—» on the printed circuit. In order to do this, about 3 mm of the insulation should be removed from the end of the wire and the bared lead should be twisted together very tightly si that it will pass through the hole in the printed circuit board. After this the wire should be soldered to the board like any normal lead.

☐ Switch SW2
Connect the upper left tag to the point marked F on the printed circuit board. Connect the lower left tag with the point marked H on the printed circuit board.

☐ Using a piece of red insulated wire, connect the upper centre tag with the positive terminal of the meter. The correct tag on the meter is the one from which a red lead enters into the meter itself.

☐ Using a length of black insulated wire, connect the lower centre tag with the negative terminal of the meter. Connect the upper right tag with the point marked N on the printed circuit board. Connect the lower right tag with the point marked G on the printed circuit board.

4th Stage - Mounting the variable capacitor and the socket for the coils (see fig. 5)

☐ Insert the four feet of the variable capacitor (2) into their correct holes on the printed circuit board (1) and solder them in place to the copper track. The spindle of the variable capacitor must be in the direction shown in the figure.

☐ Thread the drum with the frequency graduated scale (3) on to the spindle of the variable capacitor and fix it temporarily in place using the grub screw (4).

☐ Mount the end plate (5) which holds the spindle of the variable capacitor in place fixing it in position on the printed circuit board using the screws (6) and the nuts (7). The variable capacitor spindle must enter the hole in the endplate.

☐ Mount the socket for the inter-changeable coils (9) on the supporting plate (8) making sure that the tags are arranged as shown in the figure. Fix the socket in place using the metal ring (10) and the two self-tapping screws (11).

☐ Solder a length of about 25 mm of 1 mm diameter bare wire to the lower contact of the socket and leave this pointing downwards.

☐ Fix the supporting plate (8) to the printed circuit, taking care that the soldered lead described above enters into the hole marked M on the printed circuit board (see fig. 4). The plate is fixed in place using the two screws (12) and the two nuts (13).

☐ Solder the bare wire described above to the point on the printed circuit board.

☐ With reference to fig. 4, connect the remaining two tags on the socket with the tags of the fixed plates of the variable capacitor using short straight lengths of 1 mm diameter bare wire. Connect the two capacitors C1 and C2 between the fixed plates of the variable capacitors and the points marked H and S on the printed circuit board. Mount the FET Tr1 (2N3819) taking care to note the exact arrangement of the terminal tags.

5th Stage - General Assembly (Fig. 7)

☐ Check that the position of each component is correct and that each connection has been correctly carried out.

☐ Fix the 3 hexagonal spacers (2) on the base (1) of the instrument case using the screws (3).

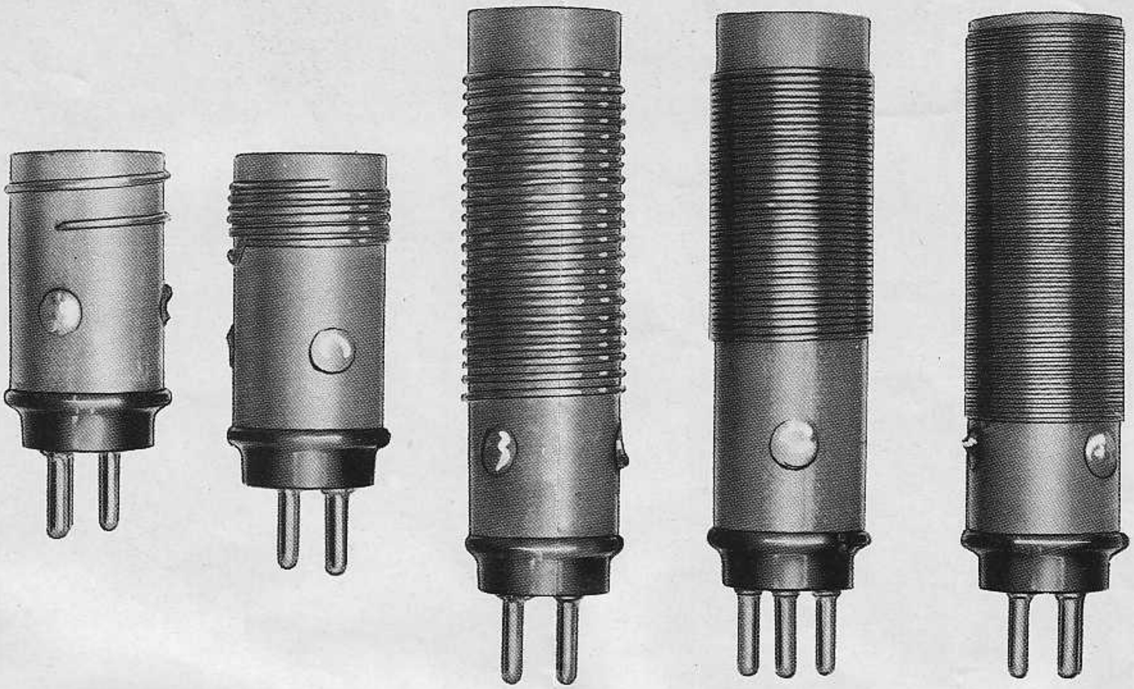


Figure 8 - Coils for the five frequency ranges.

6th Stage - Calibration

☐ Check that the main switch SW3 is in the OFF position. The switch SW1 should be in the diode position and the switch SW2 in the position marked BATT.

☐ Connect the polarised plug to the battery.

☐ Switch SW3 to the on position and adjust the trimmer P2 until the meter needle shows maximum for the voltage of the battery.

☐ Switch SW2 to the position DIP and adjust the trimmer P3 to zero the meter needle position.

☐ Switch off the main switch.

7th Stage - Complete Assembly

☐ Mount the completed printed circuit board (4) on the spacers (2) using the screws (6). The plate which holds the socket for the coils must be fixed to the case with the self-tapping screws (5) for greater rigidity.

☐ Insert the 6 x 1.5 V torch batteries into the battery holder (7) making sure that they are inserted the correct way round. Insert the battery holder into its position in the case. The battery case is held in position with a spring clip.

☐ Glue the trasparent scale cover (8) which contains the reference line for the scale reading, on to the case cover (9).

☐ Fix the control knob (11) on to the spindle of the variable capacitor.

☐ Check the position of the graduated drum and adjust it so that, when the variable capacitor is completely open, the reference line coincides with the high frequency end of the scale. To do this the screw (4) of fig. 5 should be temporarily slackened.

☐ Glue the four self-adhesive pads (13) to the case (1).

☐ Fix the case cover in place using the four self-tapping screws (12).

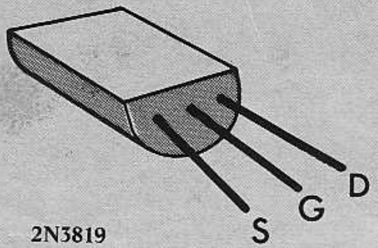
☐ Mount the knob (10) on the spindle of the potentiometer P1.

INSTRUMENT CHECK

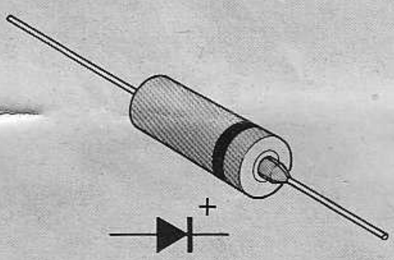
First put switch SW1 in the position OSC, and then switch on the grid-dip and adjust the instrument sensitivity so that the meter needle is roughly in the centre of the scale. Make up a tuned circuit containing an inductance coil and a suitable capacitor in parallel, plug a coil into the grid-dip and sweep slowly through the frequency scale. If no dip occurs change the coil for another one chosen from the 5 provided with the instrument (fig. 8). At a particular point, the meter needle will jump rapidily up the scale. Move the instrument away to reduce the coupling to the tuned circuit until the meter movement is hardly perceptible when the knob of the variable capacitor is moved through the tuned position. It is better that instrument is held in a fixed position whilst any measurement is taken in order that any small movement of the meter needle is not confuse with that produced by a movement of the instrument itself. The precise procedure and the precaution which are necessary during the measurement have already been given above together with some of the different possible ways in which the instrument can be used.

If the instrument is coupled to an active, i.e. powered, oscillator circuit, the meter needle can move in the opposite direction towards the lower part of the scale. Use of the diode detector to measure active circuits is less precise and sensitive but it is the only method which does not produce an effect with parasitic signal upon the circuit under examination.

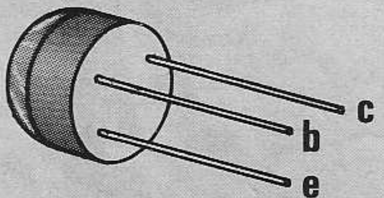
ARRANGEMENT OF THE CONNECTING LEADS ON THE SEMICONDUCTOR COMPONENTS



2N3819



AA119



BC209B

LIST OF COMPONENTS

Number	Symbol	Description
1	—	2N3819 transistor
1	—	BC209B transistor
2	D1-D2	AA119 diodes
1	R1	1 MΩ resistor
1	R2	680 Ω resistor
1	R3	33 kΩ resistor
2	R4-R5	2.7 kΩ resistors
1	R6	100 kΩ resistor
2	C1-C2	100 pF tubular capacitors
1	C3	4.7 pF NPO disc capacitor
1	C4	1 nF disc capacitor
1	C5	10 nF disc capacitor
1	—	90 + 90 pF variable capacitor
1	—	4.7 kΩ/A trimmer
1	—	10 kΩ linear potentiometer
1	—	22 kΩ trimmer
1	Z1	R.F. choke
3	—	slider switches
1	—	meter
1	—	printed circuit board
1	—	drum with graduated scale
1	—	pointer knob
1	—	knob (with reduction sleever for 4 mm)
1	—	diameter spindle
1	—	polarised plug
1	—	case
1	—	socket with metal ring
5	—	coils
20 cm	—	red insulated wire
20 cm	—	black insulated wire
10 cm	—	1 mm diameter bare wire
20 cm	—	0.7 mm diameter bare wire
2	—	M3 nuts
4	—	M 2.6 nuts
2	—	M3 x 6 screws
6	—	M3 x 4 screws
4	—	M2.6 x 6 screws
3	—	spacers L = 48 m
4	—	2.2 x 5 self tapping screws
3	—	2.9 x 6.5 self tapping screws
1	—	screw for fixing drum on spindle
6	—	M2 x 6 screws
1	—	plate for holding spindle of variable capacitor
1	—	plate for holding coil socket
1	—	instrument bracket
1	—	transparent window with reference line
1	—	battery container
1	—	holder for battery container
1	—	solder dispenser